

## SPECIFICATION

### PRODUCTION CAPABILITY SIMULATING SYSTEM AND METHOD

#### BACKGROUND OF THE INVENTION

##### 1. Field of the Invention

[0001] The present invention relates to material requirement planning systems and methods, and particularly to a system and method for simulating production capability of a manufacturing enterprise.

##### 2. Background of the Invention

[0002] Master production schedules (MPSs) are vital for all manufacturers, especially large-scale manufacturing enterprises. An MPS is a production schedule for finished products spanning a period of time in the future. The aim of the MPS is to timely forward the finished products to relevant customers, while avoiding overloading or underutilization of production apparatus and production capacity. Usually, a manufacturer makes purchase orders for necessary raw materials and components according to production demand, buffer inventory and lead time, and transmits the purchase orders to corresponding vendors. The vendors provide the raw materials and components to the manufacturer according to the purchase orders. Changes in market supply and demand cause much uncertainty in production demand, and purchase orders frequently need to be changed or re-scheduled. If the purchase orders are not re-scheduled methodically and timely, this can lead to delays in supply of the raw materials and components, and consequent delays in production.

[0003] China Patent No. CN1277401A, published on Dec. 20, 2000, discloses a purchase order producing system. The system is executed on a computer that comprises a storage and a processor. The system comprises: a demand database

for recording demand for material in each week of a predetermined period; a buffer inventory module for calculating an average demand in each week, and for calculating a buffer inventory that should be maintained at the end of each week based on the average demand; and a purchase order module for generating purchase orders for each week based on the average demand of the week, on-hand inventory and the buffer inventory.

[0004] The above-mentioned purchase order producing system can meet demand for material only to a limited extent; that is, according to weekly cycles. The system cannot generate purchase orders according to more up-to-date production demand and material demand. Nowadays, production demand can fluctuate even daily, in order for the manufacturer to be able to quickly respond to a customer's new requirements. If material demand cannot be changed quickly to support a new production demand, the manufacturer runs the risk of late or inefficient production, having an unsatisfied customer, or even losing a customer.

[0005] Thus, a system and method is needed for simulating production capability and material demand of a manufacturing enterprise for a designated period of time in the future. Based on the results of simulation, the enterprise can produce a suitable MPS, and later modify the MPS according to fluctuations in product demand.

## SUMMARY OF THE INVENTION

[0006] Accordingly, an object of the present invention is to provide a production capability simulating system for generating a master production schedule (MPS) by simulating rough-cut capacity planning (RCCP) and material requirements planning (MRP), and for rescheduling the MPS as needed.

[0007] Another object of the present invention is to provide a production capability simulating method for generating an MPS by simulating RCCP and

MRP, and for rescheduling the MPS as needed.

[0008] In order to accomplish the first above-mentioned object, the present invention provides a production capability simulating system for simulating rough-cut capacity planning (RCCP) and material requirements planning (MRP) of a manufacturing enterprise in order to make MPSs. The production capability simulating system comprises a plurality of client computers, a database server, an MPS management server, and a network interconnecting the plurality of client computers, the database server, and the MPS management server. The MPS management server comprises a data retrieving module for obtaining data from external information systems such as a purchase order information system, an MPS generating module for generating an original MPS, and for amending the original MPS to be an optimized MPS, and a simulating module for simulating the RCCP and the MRP; Wherein the simulating module comprises a simulation mode selecting sub-module for selecting a simulation mode for performing simulation, the selected simulation mode may be an RCCP simulation mode or an MRP simulation mode; an RCCP simulating sub-module for simulating the original MPS in the RCCP simulation mode; an MRP simulating sub-module for simulating the original MPS in the MRP simulation mode; and a simulation report generating sub-module for generating simulation reports based on simulation results generated by the RCCP simulating sub-module or the MRP simulating sub-module.

[0009] In order to accomplish the second above-mentioned object, a preferred method of simulating production capability comprises the following steps: (i) selecting an original MPS to be simulated; (ii) selecting a simulation mode; (iii) simulating the original MPS and generating simulation results; (iv) generating a simulation report based on the simulation results; (v) determining whether there are contingencies that require rescheduling of the original MPS; (vi) amending the original MPS if there are the contingencies, and returning to step (iii) regarding the

amended MPS; and (vii) generating an optimized MPS if there are no the contingencies or when the contingencies have been eliminated by applicable previous steps hereof, and generating weekly production schedules based on the optimized MPS.

[0010] Other objects, advantages and novel features of the present invention will be drawn from the following detailed description of preferred embodiments of the present invention with the attached drawings, in which:

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. 1 is a schematic diagram of an application environment of a production capability simulating system in accordance with a preferred embodiment of the present invention, the system comprising an MPS management server;

[0012] FIG. 2 is a schematic diagram of infrastructure of the MPS management server of FIG. 1;

[0013] FIG. 3 is a flow chart of a preferred production capability simulating method in accordance with the present invention;

[0014] FIG. 4 is a flow chart of generating weekly schedules in accordance with the present invention;

[0015] FIG. 5 is a flow chart of simulating RCCP in accordance with the present invention; and

[0016] FIG. 6 is a flow chart of simulating MRP in accordance with the present invention.

#### DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

[0017] FIG. 1 is a schematic diagram of an application environment of a

production capability simulating system in accordance with the present invention. The production capability simulating system employs a three-tier infrastructure: a plurality of client computers 3, a master production schedule (MPS) management server 1, and a database server 4, all of which are linked via a network 2. The MPS management server 1 is linked to a purchase order (PO) information system 7, an inventory information system 8, a manufacturing order (MO) information system 9, and a production management (PM) information system 10 via the network 2. The above-mentioned external information systems 7-10 store corresponding purchase orders, inventory information, manufacturing orders, and production information in a database 5 via the network 2 and the MPS management server 1. The network 2 is an electronic communication network such as an intranet, the Internet or another suitable communication network.

[0018] The client computers 3 are distributed at different locations of an enterprise, and respectively provide interfaces for various users of the production capability simulating system. The users comprise relevant production managers. The users can access the MPS management server 1 via the client computers 3 to perform operations such as maintaining data in the database server 4.

[0019] The MPS management server 1 comprises core and mutable enterprise logic of the production capability simulating system. Such logic includes rules for execution and management of the production capability simulating system. The MPS management server 1 processes input by users, and returns results of processing to users.

[0020] The database server 4 is connected to the database 5 by a link 6. The link 6 is a kind of database connectivity, such as open database connectivity (ODBC) or Java database connectivity (JDBC). The database server 4 controls processing of data stored in the database 5. Such processing includes reading, writing, deleting, modifying, and backup.

[0021] FIG. 2 is a schematic diagram of infrastructure of the MPS management server 1. The MPS management server 1 comprises a data retrieving module 100, a data maintaining module 102, an MPS generating module 104, a simulating module 106, a weekly scheduling module 108, a querying module 110 and a printing module 112.

[0022] The data retrieving module 100 is used for obtaining information from the external information systems 7-10. For example, the data retrieving module 100 can retrieve data on purchase orders from the purchase order information system 7, retrieve data on production materials and inventories thereof from the inventory information system 8, retrieve data on manufacturing orders from the manufacturing order information system 9, and retrieve data on production management from the production management information system 10. The data retrieving module 100 also transmits manufacturing orders generated by the MPS generating module 104 to the manufacturing order information system 9.

[0023] The data maintaining module 102 is used for performing maintenance of basic data; the basic data comprising sale forecast data, the enterprise's calendar, and parameters of material codes in an MPS. Such maintenance includes addition, deletion, and modification of the basic data. The parameters of material codes comprise Available to Promise (ATP), Demand Time Fence (DTF), and Planning Time Fence (PTF). The ATP is the "uncommitted" portion of the current inventory or future planned supply of an enterprise, which is updated dynamically in real time. The DTF is a point in time between a current date and a PTF. The PTF is a point in time between a DTF and a planning horizon that is scheduled in an MPS.

[0024] The MPS generating module 104 is used for generating an original MPS, and for amending the original MPS to be an optimized MPS according to demands for rescheduling.

[0025] The simulating module 106 is used for simulating rough-cut capacity planning (RCCP) and material requirements planning (MRP) based on the original MPS. The RCCP is a process of converting an MPS into a critical production capability requirement. The critical production capability requirement comprises human resources, production apparatuses, and inventory capacity. The simulating module 106 comprises a simulation mode selecting sub-module, an RCCP simulating sub-module, an MRP simulating sub-module, and a simulation report generating sub-module (the above-mentioned sub-modules are not shown in FIG. 2). The simulation mode selecting sub-module is used for selecting various simulation modes for performing simulation. In the preferred embodiment of the present invention, the simulation modes comprise an RCCP simulation mode and an MRP simulation mode. Each of these simulation modes has respective simulation parameters. The RCCP simulating sub-module is used for simulating the original MPS when the RCCP simulation mode is selected. The MRP simulating sub-module is used for simulating the original MPS when the MRP simulation mode is selected. The simulation report generating sub-module is used for generating simulation reports based on simulation results generated by the RCCP simulating sub-module and the MRP simulating sub-module. If the simulation results are generated by the RCCP simulating sub-module, the simulation report can list workstations that have insufficient production capability. If the simulation results are generated by the MRP simulating sub-module, the simulation report can list production materials in shortage.

[0026] The weekly scheduling module 108 is used for making a production schedule of a forthcoming week based on an MPS. The MPS may be an original MPS or an optimized MPS.

[0027] The querying module 110 is used for generating queries based on query demands of clients, transmitting the queries to the database server 4, and receiving

query results returned by the database server 4. By use of the querying module 110, a client can query MPSs, purchase orders, sales forecasts, enterprise calendars, ATPs and so on. The purchase orders can be queried according to products and vendors.

[0028] The printing module 112 is used for printing the query results returned by the database 4. The printing module 112 also prints data maintained by the data maintaining module 102.

[0029] FIG. 3 is a flow chart of a preferred production capability simulating method in accordance with the present invention. At step S310, the data retrieving module 100 retrieves up-to-date data on purchase orders and data on sales forecasts from the purchase order information system 7, retrieves inventory data from the inventory information system 8, and retrieves data on manufacturing orders from the manufacturing order information system 9. The data retrieving module 100 can list the data on purchase orders in order of importance thereof. At step S312, the data maintaining module 102 maintains MPS parameters, such as production modes, ATPs, DTFs and so on. The production modes comprise make to stock (MTS), make to order (MTO), and project-based production. Under the MTS mode, products are finished based on sales forecasting before the manufacturing enterprise receives orders. Under the MTO mode, products are finished based on actual orders received by the manufacturing enterprise. Under the project-based production mode, products are finished based on fixed workstations. At step S314, the MPS generating module 104 generates an original MPS pursuant to the MPS parameters. The original MPS comprises demand information, current inventory data, data of ATP, and quantities of products finished daily according to the PTF. At step S316, the simulating module 106 simulates RCCP and MRP of the enterprise, and determines whether the production capability and the production materials of the enterprise can meet

the demands of the original MPS. If contingencies arise which require rescheduling of the MPS, at step S318, the MPS generating module 104 amends the original MPS. Such contingencies may include, for example, insufficient production capability and lack of production materials. At step S320, the MPS generating module 104 generates an optimized MPS after one or more amendments of the original MPS. Afterward, the weekly scheduling module 108 generates weekly schedules that are provided to production departments for scheduling of production.

[0030] FIG. 4 is a flow chart of generating weekly schedules in accordance with the present invention. At step S410, the data maintaining module 102 selects an MPS for generating weekly schedules, and sets a scheduling rule. The selected MPS may be an original MPS or an optimized MPS. The scheduling rule may be a first maturity rule, a shortest process time rule, an urgency rule, or a first in, first out (FIFO) rule. The first maturity rule means that if the maturity date of an order is earlier than maturity dates of all other orders, the earliest order should be processed first. The shortest process time rule means that if the process time of an order is shorter than that of any other orders, the order having the shortest process time should be processed first. The urgency rule means that if an order is more urgent than all other orders, the most urgent order should be processed first. The FIFO rule means that if an order is submitted earlier than all other orders, the order submitted earliest should be processed first. At step S412, the weekly scheduling module 108 generates weekly production schedules based on purchase orders, inventory data, orders, and the selected MPS. The weekly production schedules comprise a finished quantity of each product on each day, and a starting time, a completion time and a maturity date of each order. At step S414, a user determines whether the weekly production schedules are complete and accurate. If any weekly production schedules are not complete and accurate, at step S416,

the weekly scheduling module 108 amends such weekly production schedules, whereupon the procedure returns to step S414. If and when all the weekly production schedules are complete and accurate, at step S418, the user determines whether there are any contingencies that would require rescheduling of any of the weekly production schedules. The contingencies may include, for example, changes to orders, failure of production apparatus, changes to MOs, and production of faulty products. If any of said contingencies exist, at step S416, the weekly scheduling module 108 amends the relevant weekly production schedules, whereupon the procedure returns to step S414.

[0031] FIG. 5 is a flow chart of simulating RCCP in accordance with the present invention. In this flow chart, for the purposes of best illustrating the present invention, the simulation of the RCCP is based on an original MPS. Simulation of RCCP can enable users to evaluate how an MPS influences a production bottleneck. The production bottleneck may be a production department, or a production apparatus. At step S510, the simulation mode selecting sub-module selects the RCCP simulation mode for performing simulation. At step S512, the RCCP simulating sub-module of the simulating module 106 simulates the original MPS in the RCCP simulation mode, and according to a default scheduling rule. The default scheduling rule may be any one of the first maturity rule, the shortest process time rule, the urgency rule, and the FIFO rule. Based on simulation results generated by the RCCP simulating sub-module, the simulation report generating sub-module generates a production capability report that lists workstations that have insufficient production capabilities. At step S514, the simulating module 106 determines whether each workstation has a sufficient production capability, especially those workstations that were indicated in the report to be production bottlenecks. If all workstations have sufficient production capability, at step S518, the original MPS is set as an optimized MPS, and MRP is

run on the optimized MPS. If there are some workstations that do not have sufficient production capabilities, at step S516, the MPS generating module 104 amends the original MPS to enable one of those workstations to have sufficient production capability to meet the demands of the amended MPS, whereupon the procedure returns to step S512 in relation to the amended MPS. This loop continues running until the amended MPS has been amended such that all workstations have sufficient production capabilities to meet the demands of the amended MPS.

[0032] FIG. 6 is a flow chart of simulating MRP in accordance with the present invention. Simulation of MRP enables users to effectively control the supply of all production materials. In this flow chart, for the purposes of best illustrating the present invention, the simulation of the MRP is based on an original MPS. At step S610, the simulation mode selecting sub-module selects the MRP simulation mode for performing simulation. At step S612, the MRP simulating sub-module of the simulating module 106 simulates the original MPS in the MRP simulation mode and according to a default scheduling rule. The default scheduling rule may be any one of the first maturity rule, the shortest process time rule, the urgency rule, and the FIFO rule. Based on simulation results generated by the MRP simulating sub-module, the simulation report generating sub-module generates a production material report that lists production materials that are in shortage. At step S614, the simulating module 106 determines whether there are any production materials in shortage in the material report. If there are no production materials in shortage, at step S618, the original MPS is set as an optimized MPS, and MRP is run on the optimized MPS. If there are some production materials in shortage, at step S616, the MPS generating module 104 amends the simulated MPS to enable one of the production materials in shortage to meet the demands of the amended MPS, whereupon the procedure returns to step

S612 in relation to the amended MPS. This loop continues running until the amended MPS has been amended such that all production materials in shortage are able to meet the demands of the amended MPS.

[0033] Although only preferred embodiments of the present invention have been described in detail above, those skilled in the art will readily appreciate that many modifications to the preferred embodiments are possible without materially departing from the novel teachings and advantages of the present invention. Accordingly, all such modifications are deemed to be covered by the following claims and allowable equivalents of the claims.